Black Mountains Predation Management Plan

Arizona Game and Fish Department
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Introduction

This management plan has been developed to address mountain lion predation on a depressed desert bighorn sheep population located in the Black Mountains of northwestern Arizona. The plan follows the spirit and guidance of the Arizona Game and Fish Commission Predation Management Policy and the Arizona Game and Fish Department Predator Management Team Report.

Specifically, the Arizona Game and Fish Commission Predation Management Policy states:

> "Actions by the Arizona Game and Fish Department (Department) should be based on the best available scientific information. Mountain lions and coyotes will be managed to ensure their future ecological, intrinsic, scientific, educational, and recreational values, to minimize conflict with humans, and to minimize adverse impacts on other wildlife populations.
>
> The Department will develop site-specific management plans when either of these two species is considered to be inhibiting the ability of the Department to attain management goals and objectives for other wildlife species."

Furthermore, the Department's Predator Management Team Report states that; "Predators and their prey cannot be managed separately" and that "as a Department we must strive to develop the biological and social data necessary to manage predators with a program that is biologically sound and publicly acceptable."

Area Description

The project area consists of Game Management Units (GMUs) 15B West, 15C North, 15C South, and 15D (Appendix 1) in the Kingman Region of the Arizona Game and Fish Department. These units cover approximately 1425 square miles. Topography is generally composed of vertical cliff faces, rugged canyons, mesas, boulder-strewn terrain, rolling hills, and broad alluvial valleys. Elevations range from less than 1,000' in the Colorado River valley to approximately 5,460' on Mt. Perkins. The predominant vegetation type is Mohave Desert Scrub. Common plants include creosote bush (*Larrea tridentata*), bursage (*Ambrosia dumosa*), catclaw acacia (*Acacia greggii*), paper bag bush (*Salazaria mexicana*) brittlebush (*Encelia* spp.), Mormon tea (*Ephedra* spp.), barrel cactus (*Ferocactus* spp.), hedgehog cactus (*Echinocereus* spp.), teddy bear cholla (*Opuntia bigelovii*), Mohave yucca (*Yucca schidigera*), as well as juniper (*Juniperus monosperma*) and turbinella oak (*Quercus turbinella*) at higher elevations.

Statement of Need

In 2002, range conditions in the Black Mountains were extremely poor. Rainfall recorded at the Kingman office of the Arizona Game and Fish Department for 2002 was only 3.38 inches (Appendix 2). Average annual rainfall recorded in Kingman from 1931-2005 is 10.31 inches with below average rainfall between 1999 and 2002. This data comes from a single rain gage maintained by Arizona Game and Fish Department but similar climatic conditions were documented Region-wide.

Severe drought can have a negative impact on plant communities, water distribution, and dependent animal populations. Poor plant production can influence animals by reducing reproduction and recruitment, causing home range shifts or direct mortality, and allow endemic or introduced diseases to further stress nutrient-weakened animals. Also, limited water sources force animals to spend more time near available water, increasing the risk of predation and disease transmission.

During the 2002 sheep hunting season, several sheep hunters, their scouting partners, and hunt guides reported finding numerous sheep skulls (pick-up heads) in 15C North and 15C South. Department staff met with a guide on May 7, 2003. He picked up 16 ram heads during the 2002 hunt. Eight of the heads came from 15C North and 8 came from 15 C South (Appendix 3). Based on rate of decomposition and amount of bleaching, it was determined that 2 of the 15C South sheep and 7 of the 15C North sheep had died in the last 12 months (Appendix 4). Of the remaining skulls examined, 3 appeared to have died within the last 2 years, and 3 greater than 2 years ago. One horn sheath was found without a skull, therefore time since mortality for this sheep could not be determined. The guide also picked up an additional 5 ram heads shortly after the sheep hunt. One of the guide's clients found 3 additional ram heads during the hunt. The additional heads were not available for examination. Other sources reported finding pick-up heads in the northwestern part of the Region but Department staff did not have access to these heads.

Various people including wildlife managers, National Park Service staff, BLM staff, hunters, outdoor recreationists, and others discover dead sheep annually in this area. No baseline data exists on the number or condition of dead sheep found for previous years and data for 2002 is at best incomplete. There is likely a reporting bias for ewes and lambs. Ewe and lamb skulls are not as desirable and probably are not collected or reported as often as big rams. In addition, because of their small size and horns, many of these skulls are completely devoured by rodents and predators. Although the Department does not have any trend data on pick-up heads, the reported number of dead sheep found shortly before and during the 2002-hunting season may be an indication of a downward trend in the population caused by the influence of drought, disease and predation.

The Kingman Region normally conducts bighorn sheep surveys on a rotational basis every 3 years. In 2003, 15C South was the main unit scheduled for helicopter survey on this rotation. The Region secured additional Wildlife Conservation Fund money to survey 15C North and 15B West to help determine if the area had suffered a recent population decline. Total numbers of sheep observed were below average and the number of sheep seen per hour was down (Appendices 5-7). In 15C South, 4.0 bighorn sheep were seen per hour of survey effort, an 84% decrease from the 1995-2001 average of 25.5 bighorn sheep seen per hour of survey effort. This was an area where many older age class rams had been found dead. In fall 2004, helicopter bighorn sheep surveys were flown in all the Black Mountains, including 15D. In 15B West, 15C North, and 15C South, numbers were again well below average but close to where they had been in 2003. In 15D, numbers were slightly below average, but the population appeared to be stable (Appendix 8). In 2005, additional funds were acquired to fly spring surveys in 15CS in addition to the traditional fall surveys to target monitoring efforts on the sheep population with the largest declines. Fall surveys indicate the population remains stable compared to the previous 2 years. Higher numbers of sheep were seen on the spring survey than during the fall survey even though they were conducted during the same year (Appendix 10). It is not clear whether this is due to seasonal immigration into the area, higher visibility rates, or a combination of factors. Spring and fall surveys will be continued in 2006, which will provide better comparative data for predicting trends in the population.

Although not normally a concern with a healthy population, there are concerns that predators may be depressing or inhibiting recovery of the population in this area because the sheep population is so low, particularly in 15C South. Declines in the Peninsular and Sierra Nevada populations of bighorn sheep, which are currently listed as endangered by the USFWS, have been attributed to a combination of mountain lion depredation and disease. Other populations, such as the San Gabriel Mountains herd in California, have declined from over 500 animals to less than 90 since 1989 almost exclusively attributed to mountain lion depredation (CA Dept. of Fish and Game).

The Department developed an action plan to include disease monitoring, radio telemetry monitoring, and foot and aerial surveys for bighorn sheep. Thirty sheep were captured near Hoover Dam as part of a highway crossing study and 19 more sheep were captured in 15C South to be tested for disease and fitness level. Blood was drawn from all sheep captured and they were fitted with radio collars to monitor them for movement and mortality. Titers from several diseases were identified from these sheep including anaplasmosis, EHD/bluetongue, and parainfluenza. Some sheep had low levels of Vitamin E as well, indicative of sheep in poor condition. In 2005, an additional 21 sheep were captured in Units 15CS and 15D and fitted with radio-collars to monitor the effectiveness of sheep crossings on State Highway 68.

With the data that has been collected, it is evident disease and drought has had a major impact on the sheep population in GMU 15. Documented mortality of radio-collared sheep since April 2004 indicates predation is having an impact on the remaining population and may inhibit future recovery. Nineteen of 28 recorded mortalities of radio-collared sheep from April 2004 to March 2006 are attributed to mountain lion predation. Of the 28 total recorded mortalities on radio-collared bighorn sheep, 16 were ewes, 12 were rams; while 11 of the 19 mortalities attributed to lion predation were ewes, and the remaining 8 were rams. Cause of death was investigated for several additional bighorn sheep mortalities, but could not positively be attributed to mountain lions because of carcass condition. Over 25% of the radio-collared sheep on the 3 study areas (e.g., Hoover Dam, GMU 15CS, and Highway 68) have been killed by mountain lions in a two-year period. Actual percentages would be significantly higher without the addition of the Hwy 68 study animals that have only been collared since November 2005. Surveys by Department personnel and expert lion hunters have revealed additional mountain lion predation. Several old mortalities were discovered in the vicinity of radio-collared sheep mortalities. Mountain lion predation on sheep within the Black Mountains appears to be higher than it has been in the past. Similar highway crossing research conducted in the same area (Cunningham and DeVos, 1992) found only one mountain lion caused mortality out of 12 total mortalities during the 1989-1991 study period. Research indicates that predator removal may be warranted and successful if certain criteria are met (Appendix 11, Predator Management Triggers Report). The low sheep population, extent of documented lion predation, and observed high lion populations in relation to available habitat indicate these triggers have been met.

As of April 2004, 12 collared sheep died as a result of predation in the northern portion of the Black Mountains and 7 collared sheep died of predation on the Southern end of the range. In the course of investigating these mortalities, other sheep carcasses were discovered. These mortalities indicate that predation, particularly by mountain lions, is a significant factor in these areas that have already been impacted by disease and drought. A reduction in the number of offending mountain lions and lions in areas where lions are known to be killing sheep within the project area through the use of sport harvest and contract services is deemed necessary to stop any further population decline and ensure the recovery of the Black Mountains bighorn sheep population.

Management Goals

The primary goal of this predation management plan is to aid in the recovery of the Black Mountains bighorn sheep population, which has recently suffered severe population declines. This will be accomplished by reducing predation on the bighorn sheep by reducing the number of mountain lions killing bighorn sheep or found in areas where mountain lions are known to be killing bighorn sheep in the Black Mountains. Disease and nutritional stress are thought to be the most likely causes of the initial population decline. However, predation on the reduced population may significantly delay or inhibit population growth, despite the recent improvements in range conditions following record rainfall. Recent research (Sawyer and Lindzey 2002, and McKinney et al. 2004) indicates mountain lions can have a population level effect on bighorn sheep. Anecdotal information from surveys by lion hunters and Department personnel indicate lion populations have remained high despite reductions in prey populations. It would be advantageous to maximize sheep survival and reproduction rates by reducing the resident lion population while habitat conditions are improving.

Strategies and Management Actions

There are several strategies that may be used to reduce mountain lion numbers within the project area. A multiple lion bag limit has already been authorized for this area. Since its inception in 2004, the multiple lion bag limit has resulted in the removal of 4 lions by sport harvest. While this strategy has shown a small measure of effectiveness, other management actions will need to be implemented to ensure an adequate removal of offending lions or lions in areas where lions are known to be killing bighorn sheep to benefit bighorn populations. Other measures that may be used to remove mountain lions in the Black Mountains include snares, leg-hold and box traps, aerial gunning, shooting, and hunting with the aid of hounds or other approved methods. USDA APHIS - Wildlife Services (Wildlife Services) will be contracted to perform most of the removal. Department employees may also be authorized to remove lions from the management area or direct other individuals to remove offending lions and lions in areas where lions are known to be killing bighorn sheep.

Management actions that can be used in this situation may be limited because of legal constraints. Because of restrictions listed in Arizona Revised Statutes (A.R.S.) 17-301, the Department is precluded from the use of leg-hold traps and snares on public lands other than for research purposes. However, the use of these methods of take will be pursued on private property when lion depredation on bighorn sheep is occurring in or near the area. Live traps (box traps) were investigated for possible use on Federal lands within the Black mountains. Consultation with Arizona Wildlife Services indicates the use of live traps is not feasible. In addition to the logistics of transporting these traps into remote locations, there is not a ready source of these traps available and it has not been proven to be an effective method of capture. If new information or a source of traps becomes available, this method will be evaluated for use at a later date. At certain times of the year (the coolest times of the year), the most effective method of take to achieve predator management is the use of lion hunters employed by Wildlife Services or through a private contractor.

Our overall goal is to remove offending lions or lions in areas where lions are known to be killing bighorn sheep through the use of contract services or sport harvest. Up to 70% of the mountain lion population within the project area may be removed while it is known that lions are killing bighorn sheep. Removal efforts will target offending lions and be concentrated in areas where lions are known to be killing bighorn sheep. Removing 70% of the lions in areas where lions are known to be killing bighorn sheep is a level demonstrated to provide an effective benefit (Ballard et. al. 2001) to bighorn sheep populations. The Department's best population estimate for the project area is at least 15 mountain lions. This estimate is based on reviews by local mountain lion experts and informal surveys

by Department personnel. With an estimated population of 15 mountain lions and a 70% removal rate, it will be necessary to remove up to 10 offending lions or lions in areas where lions are known to be killing bighorn sheep until the bighorn sheep population recovers to an acceptable level.

Following is a description of previous strategies and management actions that have taken place prior to the initiation of this predation management plan. In an effort to assess the situation and prescribe management actions that would aid in the recovery of the severely reduced bighorn sheep population in GMU 15, the Region developed the following action plan matrix. The status of each action item also is listed.

Kingman Region Bighorn Sheep Population Action Matrix

TASK	OWNER	COMPLETION DATE	COMMENTS	STATUS
Investigate pickup heads found by guide	Region Staff	May 2003	15 sheep skulls plus 1 horn from a ram examined	COMPLETED
Respond to hunter concerns re: potential sheep die off in Kingman Region	Region Staff	Summer 2003	Regional Supervisor met with interested parties and Game Specialist requested funding for extra sheep surveys	COMPLETED
Bighorn Sheep flights in 15CS, 15CN, 15BW	Region Staff	Annually	21 hours of survey time. Supplemental flights conducted in 15CS	COMPLETED
Ground Surveys (Hunters)	Region III sheep hunters	Ongoing	Data will be compiled by January 31, 2004	COMPLETED 2003 COMPLETED 2004 COMPLETED 2005
Survey hunters for #, location, and condition of sheep carcasses	Region Staff	Ongoing	Request included with info packet, information compiled by 1/31/04	COMPLETED 2003 COMPLETED 2004 COMPLETED 2005
Pre and post hunt ground surveys (Regional personnel)	Region staff	March 2004	Surveys primarily in 15CS	COMPLETED 2004 INCIDENTAL 2005
Sheep Capture and Disease testing in 15CS	Region Staff & Research Branch	April, 2004	18 Sheep captured, radio collared, and tested for disease	COMPLETED 2004 TELMETRY ONGOING
Mail packets to hunters with request for blood samples and survey information	Region Staff	November 21, 2004	Packets to include classification info, survey forms, and blood tubes	COMPLETED
Collection of blood samples from all units and lung samples from 15CS &15D	Region sheep hunters, Region and Research Branch Staff	During Annual sheep hunts 2003-2005	Will test for various diseases, samples will be sent to qualified labs.	COMPLETED 2003 COMPLETED 2004 COMPLETED 2005

Utilize disease testing data collected from sheep collared during the Hwy 93 monitoring study	Research Branch, Region staff	Ongoing	Collect blood and monitor marked sheep for various mortality factors	INITIAL ANALYSIS COMPLETED, ADDITIONAL ANALYSIS PENDING
Summer waterhole counts	Region staff	Summer 2004	Use remote cameras and observers to count and classify sheep at specified water sources	COMPLETED 2004 Discontinued 2005

The Region and Department also has conducted the following actions:

- Monitoring of radio collared sheep for mortality and general movement.
- Two presentations to the Arizona Desert Bighorn Sheep Society to provide up-to-date information on current status of the bighorn sheep situation.
- Working with the U.S. Bureau of Land Management (BLM) on grazing management actions within the Black Mountains (Big Ranch A Allotment) that may affect forage availability for bighorn sheep. Domestic livestock may also act as a buffer species maintaining lion populations at a level higher then the habitat would normally support (Rominger, et al, 2005).
- Initiated a multiple lion harvest objective in GMU's 15B West, 15C North, 15C South, and 15D.
- Work with BLM to implement burro removal efforts to meet burro population levels (AMLs) approved in the *Black Mountain Ecosystem Plan.*
- Directed sport hunters to the multiple harvest objective area.
- Region III Staff received lion field tracking training by local lion expert.
- Region III Staff and lion expert surveyed 15B West and 15C South for lion sign.
- Additional fall sheep surveys in 15C South.
- Work with state and federal land management agencies and Arizona Department of Transportation (ADOT) during project planning and scoping to minimize impacts to bighorn sheep for Highway 95 realignment.
- Work with ADOT to evaluate the effectiveness of wildlife underpasses on Highway 68.
- Maintained water developments and hauled water in GMU 15 (Appendix 12).

In addition, the following actions are being considered.

- Springtime surveys to monitor lamb survival and population status in 15C South.
- Continuation of out-of rotation sheep surveys in 15C South.
- Continue our existing action plan process.
- Discussion and possible continuation of research opportunities regarding lion/sheep interaction, and highway and other development impacts to the GMU 15 bighorn sheep population.
- Continued radio-marking and monitoring of bighorn sheep in GMU 15.

Intensity and Duration of the Actions

Due to the rugged and remote nature of the project area, hunting lions with hounds in this area is difficult even under the best tracking conditions. Several lion hunters have hunted this area since spring 2004, but only 4 lions have been taken through sport harvest. Trapping or snaring in compliance with A.R.S. 17-301 may also be utilized at any time during the year. Hunting lions with hounds is generally most effective during the cool season (November through March) due to heat stress on the dogs and the fact that lion scent dissipates quickly during warm, dry periods. Wildlife Services typically will send only one hunter at a time. It is difficult to predict how long it will take to meet removal objectives, especially if the use of hounds is not effective. The population targets for the bighorn sheep population discussed below have been established to function as triggers for completion of this project. A secondary goal of removing 10 offending lions or lions in areas where lions are known to be killing bighorn sheep during one calendar year within the project area through the use of contract services or sport harvest will serve as a secondary trigger for completion of this project unless lion depredation on bighorn sheep continue to be observed or documented in the project area. If lion depredation on bighorn sheep continues to be observed or documented in the project area, the use of contract services to remove offending lions or lions in areas where lions are known to be killing bighorn sheep may continue.

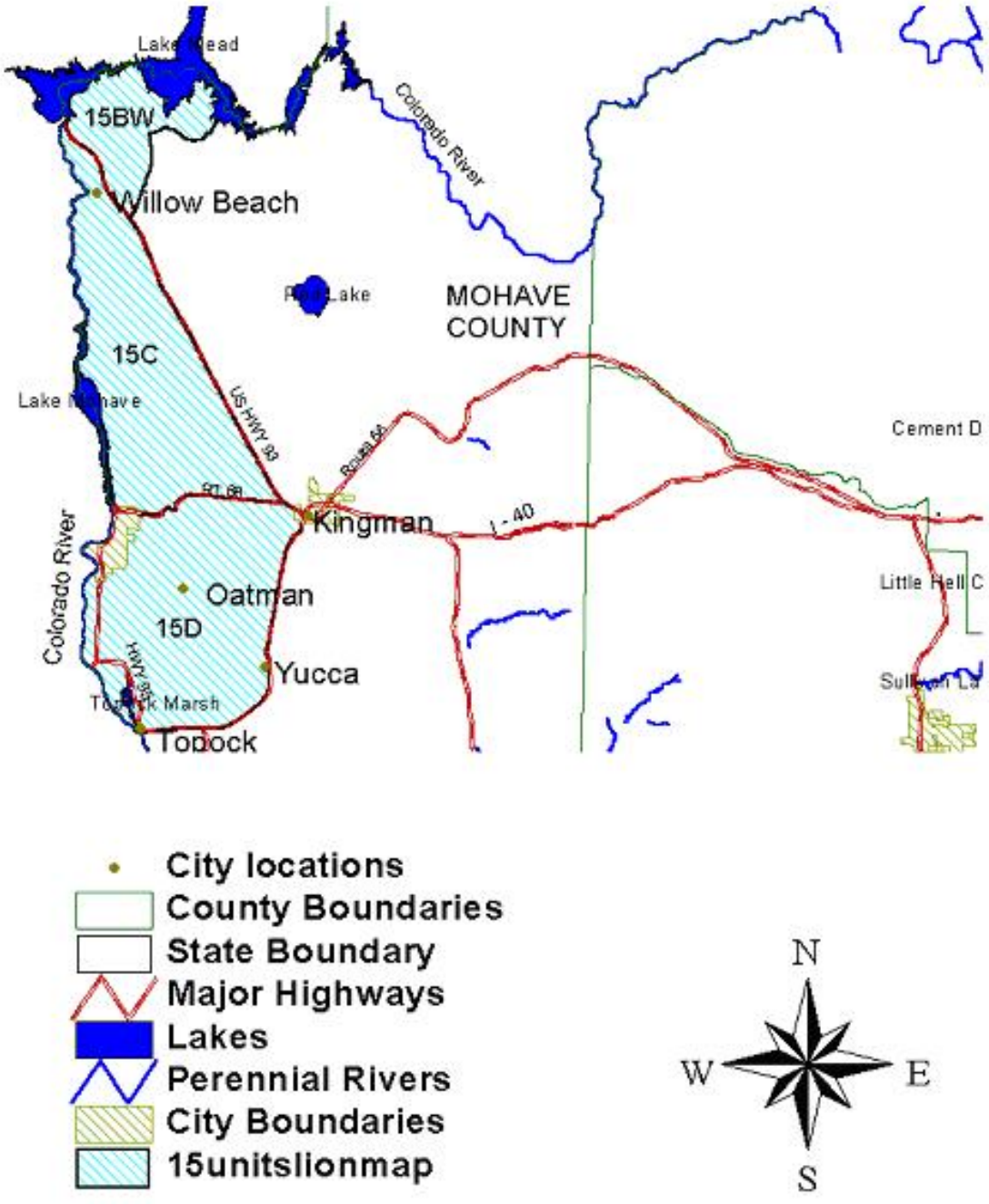
This is consistent with the Harvest Objective of 10 lions in a calendar year for sport harvest in Commission Order 10. The current bag limit for lions in Game Management Units 15B, C and D is one lion per day until the Harvest Objective of 10 lions in a calendar year is met, at which time the bag limit reverts back to one lion per year. Contract removal of lions will be discontinued prior to meeting this target if sheep population parameters are being met. In order to remove offending lions or lions in areas where lions are known to be killing sheep, it may be necessary to hunt this area during the cool season with hounds through winter 2009-2010. Because of the extended time frame necessary to achieve recovery of this bighorn sheep population, the Department will re-evaluate this trigger if our sheep population objectives are not being met and/or observed or documented lion depredation on bighorn sheep continues within the project area.

Measurable Objectives

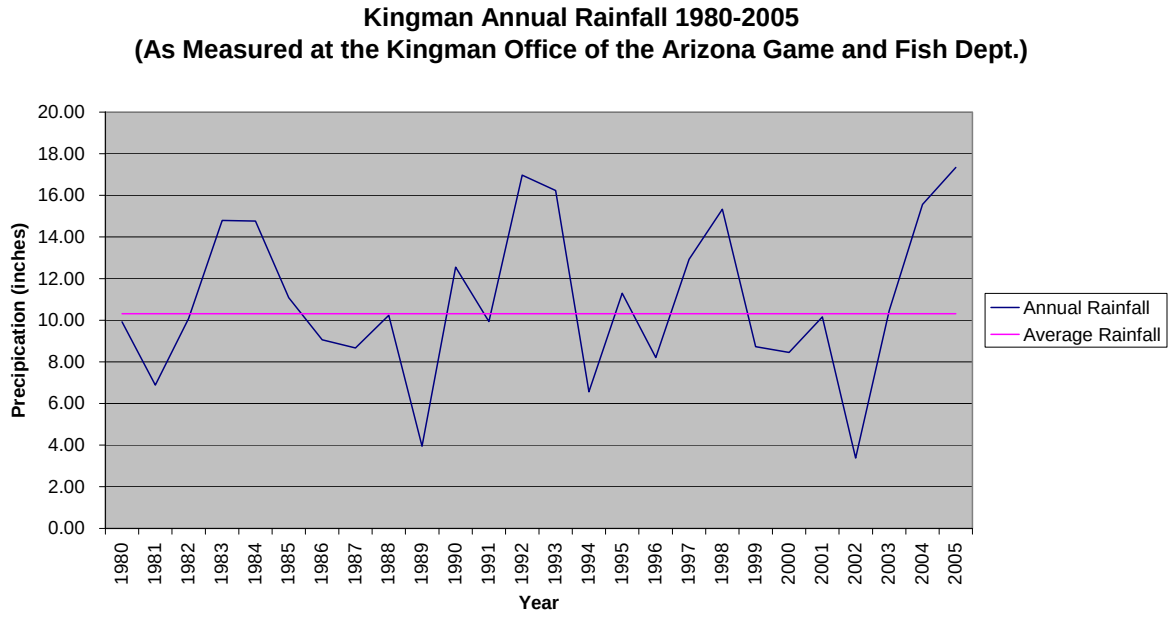
Measurable objectives include recovery of the bighorn sheep population within the project area based on population parameters and number of lions removed during the project. Both of these objectives will be used as triggers to determine completion of this project. Sheep surveys will be conducted in the fall to monitor population parameters. Unit 15CS will be used to monitor recovery of the population as it lies in the center of the project area and has experienced the largest decline in sheep population to date. The first trigger involves an indication that the sheep population in 15C South has recovered to long-term average levels. It consists of two components derived from the fall surveys, both of which must be met simultaneously to be considered sufficient. The first component will be activated when the number of sheep per hour reaches the long-term (1981-2000) average of 18.1 sheep/hour seen during a survey. The second component will be activated when the average number of sheep observed on an October survey reaches the long-term average number of sheep seen (>108 total sheep) with comparable amount of survey effort. The second trigger will involve the number of lions removed within the management area and will monitored with mandatory lion hunter check-in and Department contract services reporting. When 10 lions have been removed by any combination of the proposed methods (e.g., sport harvest or contract services) in a calendar year, the contract removal program will be stopped for that calendar year until a review of its effectiveness can be completed unless observed or documented lion depredation on bighorn sheep continues within the project area.

Appendix 1.

Proposed Predator Management Area



Appendix 2. Kingman Regional Office Annual Rainfall.



Appendix 3. Photographs of pick up heads collected by the sheep guide in 2002.

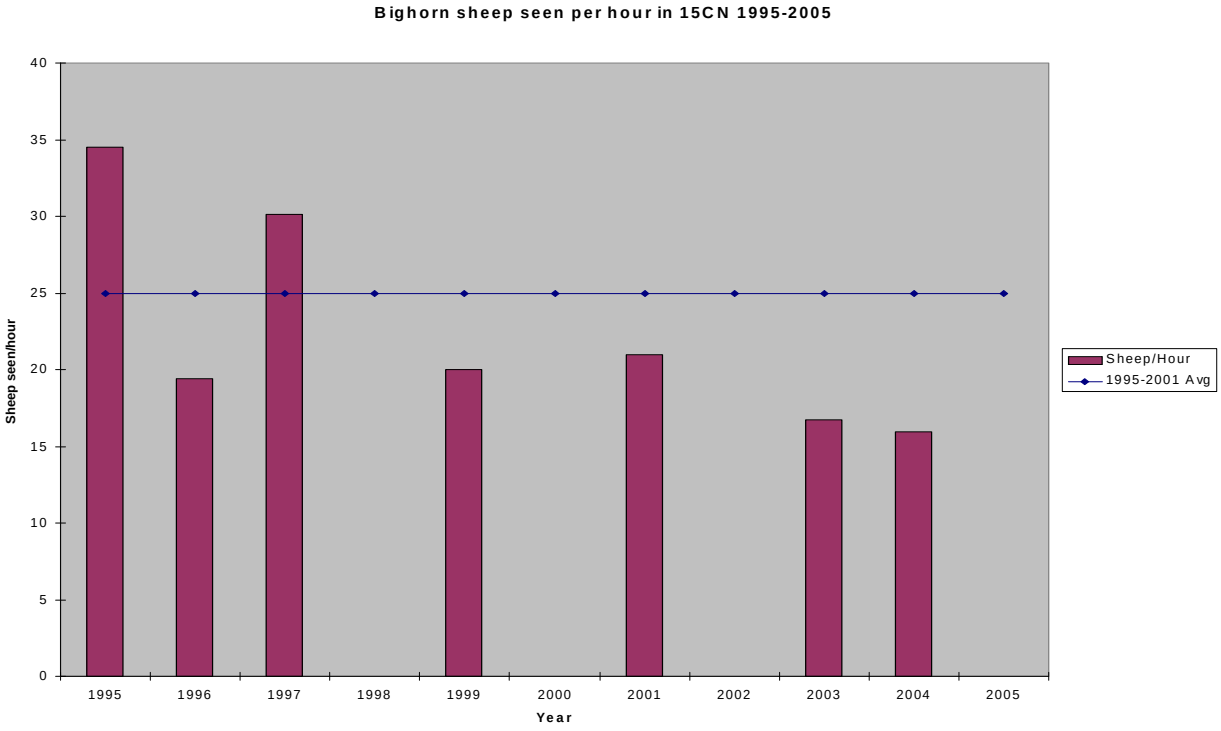
Appendix 4. Results of sheep pick up head examination from the sheep guide's collection.

*Age (Years)	Time Since Mortality (Months)	Unit
4	<12	15CN
7.5	<12	15CN
7.5	<12	15CN
8	<12	15CN
9	<12	15CN
9	<12	15CN
9	<12	15CN
8.5	12-24	15CN
6.5	<12	15CS
8	<12	15CS
8.5	12-24	15CS
9.5	12-24	15CS
5.5	>24	15CS
7.5	>24	15CS
9	>24	15CS
9	Unknown	15CS

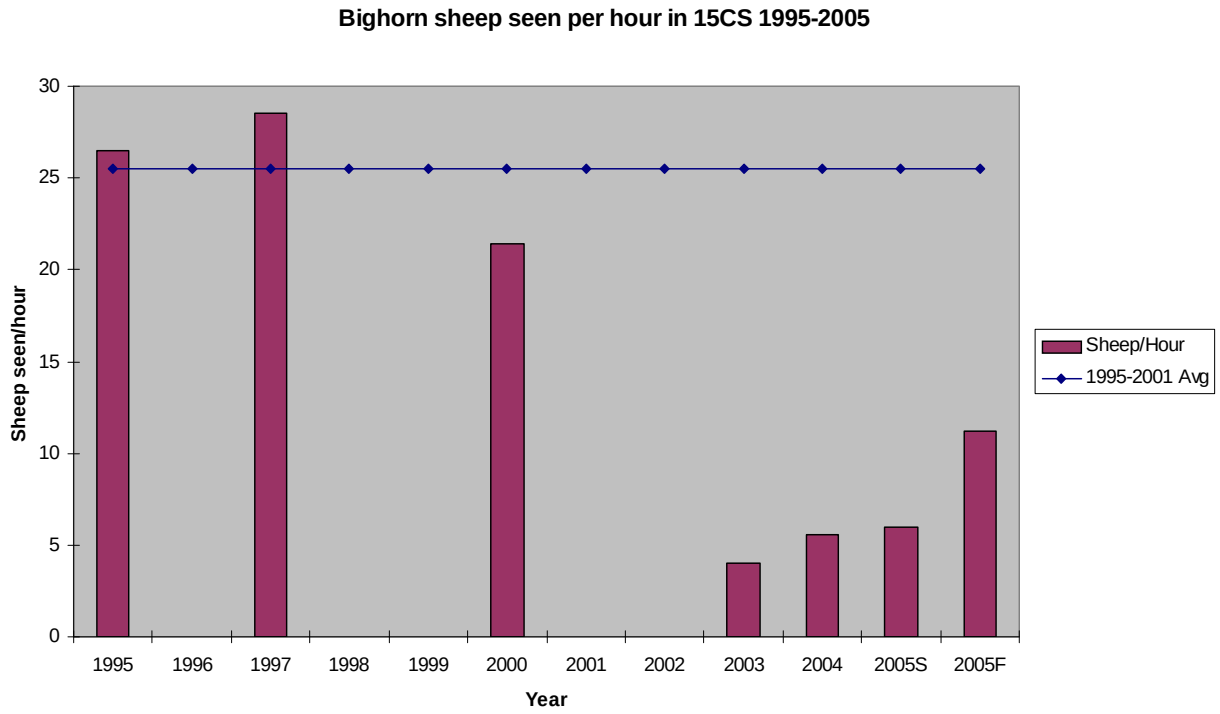
***Average age for sheep determined to be dead for less than 12 months was**
7.6 years old. Average age for sheep dead longer than 12 months was 8.1 years old.

Appendix 5. GMU 15B bighorn sheep observed per hour of survey effort, 1995-2005.

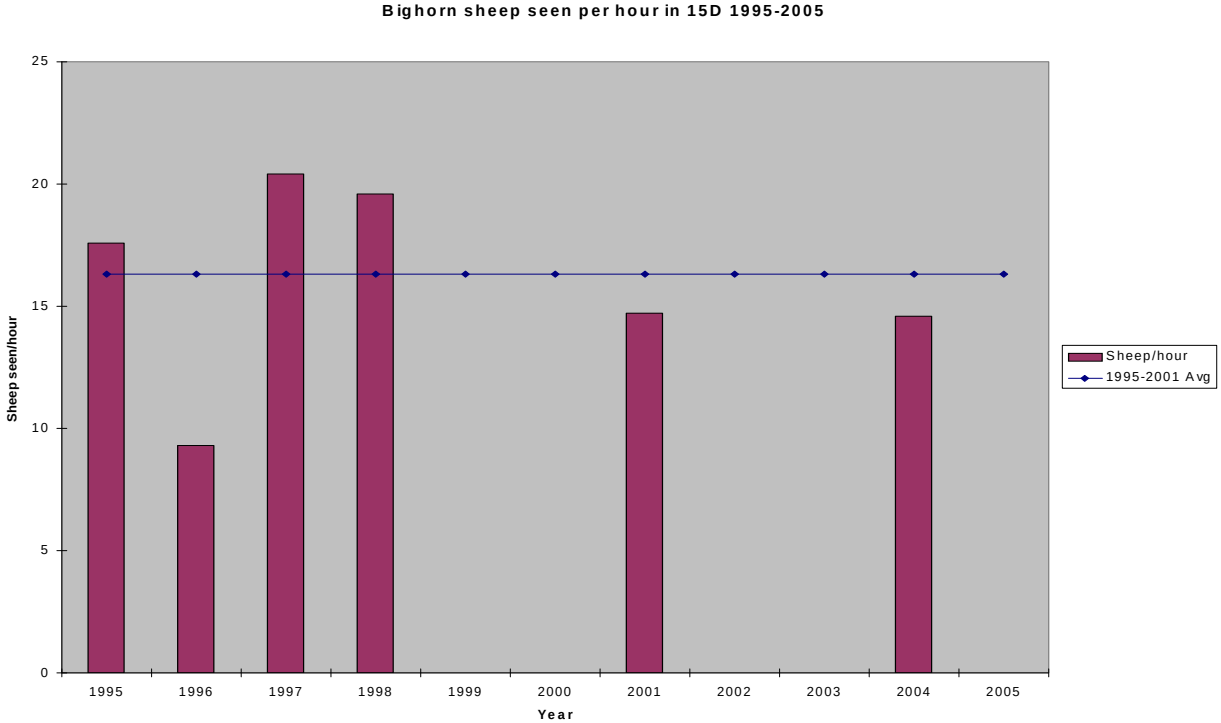
Appendix 6. GMU 15C North bighorn sheep observed per hour of survey effort, 1995-2005.



Appendix 7. GMU 15C South bighorn sheep observed per hour of survey effort, 1995-2005.



Appendix 8. GMU 15D bighorn sheep observed per hour of survey effort, 1995-2005.



Appendix 9. Combined GMUs 15B, 15CN, 15CS, 15D bighorn sheep observed per hour of survey effort, 1995-2005.

Appendix 10. Sheep survey results from 1995-2005 in GMUs 15C North, 15B West, 15C South, and 15D.

15CN								
Year	Rams	Ewes	Lambs	Yearlings	Unclassed	Total	Hours	Sheep/hour
1995	82	216	73	15	4	390	11.3	34.5
1996	68	128	21	10		227	11.7	19.4
1997	118	168	73	12		371	12.3	30.1
1998	NS	-	-	-		-	-	
1999	59	121	31	0		211	10.5	20
2000	NS	-	-	-		-	-	
2001	50	106	41	11		208	9.9	21
2002	NS	-	-	-		-	-	
2003	21	82	39	3		145	8.6	16.7
2004	18	58	43	1		120	7.51	15.97
2005	NS							
15BW								
1995	104	183	54	8		349	11	31.7
1996	64	120	15	5		204	12.1	16.8
1997	99	142	59	3		303	11.7	25.8
1998	NS	-	-	-		-	-	
1999	NS	-	-	-		-	-	
2000	31	64	18	6		119	10.9	10.9
2001	75	163	86	19		343	11.3	30.3
2002	NS	-	-	-		-	-	
2003	26	85	43	7		161	11	14.6
2004	33	64	41	4		142	8.86	16.02
2005	NS							
15CS								
1995	52	90	17			159	6	26.5
1996	NS	-	-	-		-		
1997	34	90	46	1		171	6	28.5
1998	NS	-	-	-		-		
1999	NS	-	-	-		-	-	
2000	39	65	25	2		131	6.1	21.4
2001	NS	-	-	-		-	-	
2002	NS	-	-	-		-	-	
2003	9	11	3	1		24	6	4
2004	7	17	8	2		34	6.1	5.57
2005S	8	16	6			30	5	6
2005F	13	30	14		1	58	5.2	11.2

15D								
Year	Rams	Ewes	Lambs	Yearlings	Unclassed	Total	Hours	Sheep/hour
1995	63	114	16	2		195	11.1	17.6
1996	22	30	0	4		56	6	9.3
1997	66	130	28	1		225	11	20.4
1998	43	122	39	12		216	11	19.6
1999	NS							
2000	NS							
2001	39	104	40	10		193	13.1	14.7
2002	NS							
2003	NS							
2004	29	87	25	2	1	144	9.85	14.6
2005	NS							

Appendix 11. Predator Management Triggers Report

Evaluation of mountain lion population to reverse a declining bighorn sheep population.

A number of factors will dictate whether predator reduction will influence recovery of a prey species' population. In a review of the interaction of predators and mule deer (*Odocoileus hemionus*), Ballard et al. 2001 determined that factors such as the relationship of the prey population to carrying capacity, cause of the prey population decline, climate, predator density can influence both the relationship between prey and predators, and the effectiveness of predator reduction to reduce prey populations.

Comparatively few studies have addressed impacts of predators on bighorn sheep populations, but recent findings indicate mountain lion (*Puma concolor*) predation can have population-level effects (Sawyer and Lindzey 2002). Mountain lion predation may vary among years and affect bighorn sheep population growth and production (Hoban 1990, Wehausen 1996, Creeden and Graham 1997, Ross et al. 1997, Rubin et al. 1998, Hayes et al. 2000). Variables influencing mountain lion predation are poorly documented, but might include relative availability of alternate prey and escape terrain, vulnerability of individual prey, weather, and behavior of individual predators (Leopold and Krausman 1986, Ross et al. 1997, Krausman et al. 1999, Ballard et al. 2001).

To develop a better understanding of the factors that resulted in a declining bighorn sheep population in central Arizona, McKinney et al. (2004) studied a desert bighorn sheep population in the Mazatzal Mountains during 1999–2003 to determine concurrent influences of disease exposure, nutritional status, predators, and rainfall on population growth and lamb production. Demographic indices obtained during annual surveys indicated the population declined from 1994–1997, experienced low growth and lamb production through 1999, and exhibited upward trends of growth and production during 2000–2003, despite persistent drought conditions.

Disease exposure during 2000–2002 did not correspond with livestock presence, rainfall, or dynamics and nutritional status of the desert bighorn sheep population. Evidence of bacterial and viral activity persisted during the study, and was unremarkable in comparison to bacterial prevalence, and seroprevalence and antibody titers against disease agents reported for other desert bighorn sheep populations. However, livestock removal by early 2001 was followed by lower incidence of pneumophilic bacteria in nasal swab specimens, suggesting linkage between livestock presence and bacterial exposure.

Relative nutritional status of adults and lambs indexed by concentrations of fecal nitrogen, 2, 6-diaminopimelic acid, minerals, and blood chemistry, did not prevent lamb production and population growth during 1999–2003. Forb production, forage quality, desert bighorn sheep nutritional status, population growth, and lamb production tended to be higher during wetter than drought years, but nutritional status of adults and lambs was adequate to maintain population growth and production during drought conditions. Delayed lambing in 2003 suggested marginal or deficient nutritional status during severe drought in 2002. Decline of desert bighorn sheep abundance on Mazatzal Mountains during 1994–1997 was less than declines on reference areas lacking mountain lions. Mountain lion predation was a limiting factor for radiocollared desert bighorn sheep on the Mazatzal Mountains during 1995–1998.

During 2000–2003, bobcat and coyote scats evidenced no predation or scavenging of desert bighorn sheep on the Mazatzal Mountains study area. Mountain lion reductions on Mazatzal Mountains after 1999 resulted in lower predator abundance and corresponded with higher desert bighorn sheep population growth and lamb production, despite persistent drought. We conclude winter rainfall interacted with mountain lion predation to influence growth and production of the desert

bighorn sheep population, but diet data, documented kills, and predator removal during 2000–2003 indicated predation by mountain lions was the primary, strongly additive limiting factor.

Ballard et al. (2001) concluded that there were several factors that were common to those case studies that they reviewed that dictated when predator reductions were effective and prey populations increased. These factors include:

- Predator control was implemented when the prey populations were below habitat carrying capacity;
- Predation was identified as a limiting factor;
- Control efforts reduced predator populations enough to yield results (e.g. expected to be approximately 70% of a local predator population.);
- Control efforts were timed to be most effective (just prior to predators or prey reproduction); and
- Control took place at a focused scale (generally <1,000 km^2 [400 mi^2]).

These authors further indicated that a current predator management plan needed to be in place prior to implementing predator reductions. They recommended some key elements be included in the management plan including:

- A definition of the current predator and prey population status and the desired population objective to be achieved by predator reductions.
- Desired removal goals for the predator species.
- Timing and method of removal.
- Scale of the removal effort.

In reviewing the available information on the current status of the bighorn sheep population in Arizona Game Management Unit 15, the biological triggers outlined by Ballard et al. 2001 appear to be met that would indicate that predator management would be warranted. Specifically:

- Prey population in relationship to habitat carrying capacity
- Survey data from Unit 15 show a dramatic decline in bighorn sheep population throughout the unit (AGFD unpublished data).
- Predation is identified as a limiting factor
- Of six collared bighorn sheep, five have been killed by mountain lions (AGFD unpublished data)
- Anecdotal information received from numerous sources indicate that mountain lion killed bighorn sheep
- A recent survey for mountain lions in Unit 15 documented a mountain lion population that is higher than expected given the habitat and food base for the area.

Appendix 12. GMU 15 water development maintenance activities.

Water Name	Date	Action
Lost Cabin Catchment	1/1/2005	Cleaned sediments out
	1/1/2006	Cleaned sediments out
Davis Mtn. Catchment		
Two Horns Catchment	1/1/2004	Added apron
Tufa Tank	9/19/2003	Water hauled
	10/20/2003	Water hauled
	10/20/2003	Float valve repaired, re-patched bullet holes
	1/1/2006	Walk-in drinker installed - not functioning yet
Lambing Tannk	1/1/2005	Water Hauled, painted
Black Mtns. #2	4/3/1999	General maintenance
	4/30/1999	Replaced tank cover, ultra flex apron cracks
Black Mtns. #3	7/10/1997	Water hauled
	5/19/1996	Water hauled
	7/15/2000	Water hauled
Black Mtns. #4	4/13/1999	General maintenance
	7/27/1996	Water hauled
	6/10/1997	Water hauled
	7/10/1997	Water hauled
Fire Mtn. Pothole		Non-functional - in National Recreation Area
Van Deemen Tank	1/1/2005	Cleaned sediments out, resealed
Slurry Tanks	3/24/1998	General maintenance
Pass Tank #3		
Drill Hole Tank		
Wildhorse Spring		
Wilson Ridge Spring		
Master Spring	1/4/2004	Redeveloped - sausage and drinker installed
Mcheffy Spring	11/18/1997	Cleaned spring box, cleared weeks and brush out of area unclogged line at trough
	3/18/1998	Built retention wall to divert water around trough
	1/1/2005	Cleaned sediments out
	1/1/2006	Cleaned sediments out
WL Spring		
Lazy Boy Spring		
Lower Lost Cabin Spring		
Coyote Pass Catchment	5/13/2003	Water hauled
Carl Scrivens (Cone Mt.)	1/1/2004	Built new
Middle Missouri Spring	1/1/2002	Built new
White Rock Spring		
Tipperary Tank		
Cross Seep		
Upper Twin Spring		
Metate Spfing		
Ram Springs	1/1/2006	Cleaned sediments out

Sheep Spring	3/28/2006	Cleaned sediments out of dam, removed weeds and brush from area
Columbine Spring	4/3/2006	Cleaned sediments out of dam, removed weeds and brush from area
	1/1/2005	removed weeds and brush, repaired fence
Battleship Spring	3/27/2006	Cleaned sediments out of dam, removed weeds and brush from area
Trough Spring		
Golden Door Cistern	6/15/1999	Water hauled
	9/5/2001	Water hauled
	6/6/2002	Water hauled
	1/1/2006	Redeveloped - sausage and walk-in drinker installed
Cottonwood Spring	1/1/2004	fence repaired

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Black Mountains Predation Management Plan

APPROVED: _____ DATE: _____
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